

# CODE DIVISION MULTIPLE ACCESS MOBILE COMMUNICATION SYSTEM

## TECHNICAL FIELD

The present invention relates to a mobile communication system which utilizes a code division multiple access (CDMA) system for communications between a base station and a plurality of mobile stations.

## PRIOR ART

The code division multiple access (CDMA) system is a communication system which multiplexes information sequences to be transmitted at the same frequency, by spreading them with different spreading codes for respective channels; for example, in literature 1: R. C. Dixon, "Spread Spectrum Communication System," published by Jatec, there are described in detail its system configuration and capabilities. Now, a brief description will be given of a system called a direct sequence CDMA system.

FIG. 19 shows the construction of a transmitting device in a typical CDMA communication system.  $n$  information sequences  $S1, S2, \dots, Sn$  are input into multipliers 11, 12,  $\dots, 1n$ , wherein they are spread by spreading codes  $C1, C2, \dots, Cn$  from a spreading code generator circuit 2, respectively. The output signals from the multipliers 11, 12,  $\dots, 1n$  are added by an adder 3 at the same timing to generate a transmission signal.

On the other hand, the signal received at the receiving side is despread by the same spreading codes  $C1, C2, \dots, Cn$  as those used in the transmitting device, by which the original information sequences  $S1, S2, \dots, Sn$  are generated. As the spreading codes  $C1, C2, \dots, Cn$ , code sequences are usually chosen which are excellent not only in self-correlation characteristic (letting the time offset between two correlating code sequence be represented by  $\tau$ , the correlation value is large for  $\tau=0$  and small for other values of  $\tau$ ) but also in mutual-correlation characteristic, that is, low in the correlation with other spreading codes (code sequences whose mutual-correlation value is smaller than a certain value which is offset for any given time).

On the other hand, there has been proposed a scheme of repeatedly using the same spreading code in a plurality of cells in an application of the CDMA system to a multi-cellular mobile communication system (Japanese Pat. Pub. No. 56290/83). It is expected that this scheme will make it possible to increase the number of communication channels and the system capacity.

However, very few classes of code sequences satisfy the above-mentioned requirements for spreading codes and the number of spreading codes in each class is also small. Accordingly, the conventional CDMA communication system which assigns a different spreading code to each communication channel is inevitably limited in the number of channels available for communication, and hence is not suitable for use as a radio telecommunication system of large channel capacity such as a mobile radio communication system.

With the scheme of reusing the same spreading code in a plurality of cells in the multi-cellular mobile communication system, the reuse of the same spreading code in adjacent cells that are not sufficiently far apart would degrade the channel or speech quality owing to interference or interactions, thus imposing limitations on the increase in the channel capacity.

## SUMMARY OF THE INVENTION

An object of the present invention is to provide a CDMA mobile communication system which makes it possible to effectively increase the number of communication channels through use of a limited number of spreading codes.

The mobile communication system according to the present invention which utilizes the code division multiple access scheme for communications between at least one base station and a plurality of mobile stations, characterized in:

that the base station has a transmitting device which spreads a plurality of information sequences by the same spreading code and then transmits them to the plurality of mobile stations at different timing;

that the mobile stations each have a receiving device which receives that signal from the transmitting devices of the base station which was transmitted thereto at timing predetermined therefor and despreads the received signal by the same spreading code as that used in the transmitting device, thereby reconstructing the original information sequence;

that the base station has a plurality of transmitting devices and uses different spreading codes therefor; and

that such base stations are installed at a plurality of places and those at least two predetermined ones of these base stations which are spatially far apart are allowed to use the same spreading code.

The CDMA mobile communication system according to the present invention is also characterized in:

that a plurality of base stations each have a transmitting device which spreads an information sequence by a common spreading code and transmits the spread signal to mobile stations at timing different for each base station;

that the mobile stations each have a receiving device which receives that signal from the transmitting devices of the base stations which was transmitted at timing predetermined therefor and despreads the received signal by the same spreading code as that used in the transmitting device to obtain the original information sequence;

that the transmitting device of each base station spreads a plurality of information sequences by a plurality of spreading codes and transmits the spread signals to the mobile stations at the same timing; and

that those at least two predetermined ones of these base stations which are spatially far apart are allowed to transmit the spread signals at the same timing.

The CDMA mobile communication system according to the present invention is further characterized in:

that a base station has a transmitting device which spreads a plurality of information sequences by the same spreading code and transmits the spread signals to mobile stations at timing offset by a transmitting timing offset value preset in accordance with the transmitting power used or the size of a cell which is the coverage of the base station; and

that mobile stations each have a receiving device which receives that signal from the transmitting device of the base station which was transmitted at timing predetermined therefor and despreads the received signal by the same spreading code as that used in the transmitting device to obtain the original information sequence.

In a first embodiment of the CDMA mobile communication system according to the present invention, a plurality of information sequences are spread by the same spreading code in the base station and the spread signals are transmit-